Types—Catalogue *No. 19882*, U. S. N. M., the above specimens on a slide.

2. **Arrhenophagus albipes** new species.

Female.—Length 0.40 mm.

Differs from the preceding in that all of each leg is white and the venation terminates in a small, fuscous area. Face yellowish.

Described from four females labelled as previously and "1389. *Chionaspis eugeniæ* Mask. On female scales. Hong Kong, China, Koebele."

Types—Catalogue *No. 19883*, U. S. N. M., the above specimens on a slide.

A second slide bearing many specimens labelled "Parasite of orange scurvy scale from Kiomachi, Gifu. Japan (Nawa), January 30, 1899." And another one labelled "1407. *Diaspis brasiliensis.* On fern, Jamsui. A. Koebele."

ON DIFFERENTIAL INCIDENCE OF THE BEETLE BRUCHUS.

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INTRODUCTORY REMARKS.

Beetles of the genus *Bruchus* subsisting upon the seeds of *Phaseolus, Pisum, Vigna, Vicia* and other cultivated legumes may deposit their eggs upon the young pods through which the newly hatched larvæ penetrate to the developing seed or upon the matured seed itself. *B. obtectus*, the common pest of the bean *Phaseolus vulgaris* may develop in either manner. The purpose of this note is to consider the question whether when the eggs are laid on the young pods the frequency of parasitization is in any degree determined by the characters of the pod.

The assembling of the data here presented was begun in an effort to explain certain anomalous results obtained in physiological studies of seed weight in garden beans. Since these purely botanical questions may be taken up in detail later they need not be outlined here.

I shall consider:

(*a*) The relationship between the number of ovules per pod and the relative number of seeds parasitized by the beetles.

(*b*) The relationship between the number of seeds matured per pod and the number infested by beetles.

(*c*) The relationship between the position of the seed in the pod and the incidence of the insects.

MATERIALS AND METHODS.

Unsystematized records of the incidence of the beetles are furnished after a sufficient lapse of time by the seeds themselves.

It would of course be most convenient if the pods could be preserved unopened and all the records made at one time after the emergence from the seeds of all the insects. There is, however, no reason to assume *a priori* that the insects will develop normally and emerge in full numbers in seeds remaining in the pods. Experimentally there is some evidence against such an assumption. Hence the seeds must be removed from the pods and be preserved individually with records of any of the pod characters which are to be considered.

Materials which seem to be free from pertinent objections are furnished by two lots each of several thousands of pods from my experimental cultures. One of these is a series of Golden Wax beans grown at Lawrence, Kansas, in 1906. The other is a culture of Burpee's Stringless made in the Missouri Botanical Garden in 1907.[1]

The pods of these were shelled in the fall or early winter after they were harvested. Each seed was labelled individually with a record of the characteristics of the pod from which it was taken. Such seeds as showed the presence of weevils were so designated. After some months the seeds were gone through again and other supplementary records of the occurrence of beetles were made.

The tabulation of the characteristics of the pods from which these seeds come in comparison with these of the whole series of seeds produced gives the information sought.

[1] Those who desire may obtain further information concerning the characteristics of these plants in other papers by the writer in which they are referred to by the key letters LL and GG.

Discussion of Data.

Problem I.—Relationship between the Number of Ovules formed per Pod and the Percentage of Parasitized Seeds.

In Tables I–II are shown the number of ovules formed per pod, the total number of seeds matured and the number infested by weevils.

The most logical method of comparing the numbers of infested seeds in pods with various numbers of ovules is to reduce actual frequencies to percentages for each class of pods, *i. e.*,

$$\frac{\text{Infested seeds} \times 100}{\text{Total seeds}}$$

as given in the fourth column.

TABLE I.

Infested Seeds in Golden Wax Beans.

Ovules per Pod.	Total Seeds.	Infested Seeds.	Per Cent. Infested.	Seeds Weighed.	Ratio to Weighed.
2	94	36	38.30	21	1.714
3	438	152	34.70	87	1.747
4	2,723	1,116	40.98	527	2.118
5	9,998	4,462	44.63	1,973	2.262
6	7,324	3,600	49.15	1,264	2.848
7	636	367	57.61	66	5.561
	21,213	9,733	45.88	3,938	2.472

TABLE II.

Infested Seeds in Burpee's Stringless Beans.

Ovules per Pod.	Total Seeds.	Infested Seeds.	Per Cent. Infested.	Seeds Weighed.	Ratio to Weighed.
4	768	37	4.82	421	.088
5	3,958	343	8.67	1,958	.175
6	7,657	865	11.30	3,393	.255
7	4,959	568	11.45	1,996	.285
8	1,233	166	13.46	510	.323
	18,575	1,979	10.65	8,278	.239

In both series the frequency of injury by weevils increases as the number of ovules per pod becomes larger. There is only one apparent exception: In the Golden Wax series the incidence of insects in pods with the lowest number of ovules here recorded is slightly higher than in the next higher ovule grade. The result is probably quite accidental and attributable to the fact that in these two classes relatively few pods and seeds were available. This point will be taken up below.

While the ratio of injured seeds to total seeds formed is the most logical basis of comparison, it has seemed desirable to test the results in another way. I have therefore taken the ratio

$$\frac{\text{Total Infested Seeds}}{\text{Total Seeds Weighed}^{1}}$$

for each class of pods. This purely arbitrary but useful ratio is shown in the final column of the tables. The results fully substantiate the conclusions to be drawn from the preceding method.

The trustworthiness of any percentage frequency of course depends upon its numerical magnitude and upon the number of observations upon which it is based. To determine whether the deviations from the general percentage found in the case of pods with various numbers of ovules are statistically trustworthy one may calculate the extreme range in percentage of infested seeds which one might reasonably expect to occur as a result of random drawings of samples as large as these actually considered for the particular class of pods from a series of seeds showing the percentage incidence observed in the whole material. If the observed percentages for the several classes of pods fall well outside these limits, it is clear that the deviations may be looked upon as significant.

Let N be the total number of seeds examined, Nw the total number infested by weevils. Then $Nw/N = p$, the proportion of the injured seeds. The proportion of seeds not infested by weevils is $1 - p = q$. Assuming that our general series of seeds is large enough to give trustworthy values to p and q the standard deviation of any class of seeds may be taken to be $\sqrt{mpq}$, or the standard deviation of the percentage ratio $100\sqrt{mpq}/m$, where m is the number of seeds examined in the class.

In the graphs the limits of twice the standard deviation above and

[1] Numbers of seeds from each of these series were weighed individually for breeding purposes. These were drawn quite at random.

below the population percentage has been indicated by shading in the area bounded by imaginary draughtsmen's curves smoothing the calculated standard deviations about the general percentage line. The chances are about 20 to 1 against purely random deviations falling outside the shaded areas.

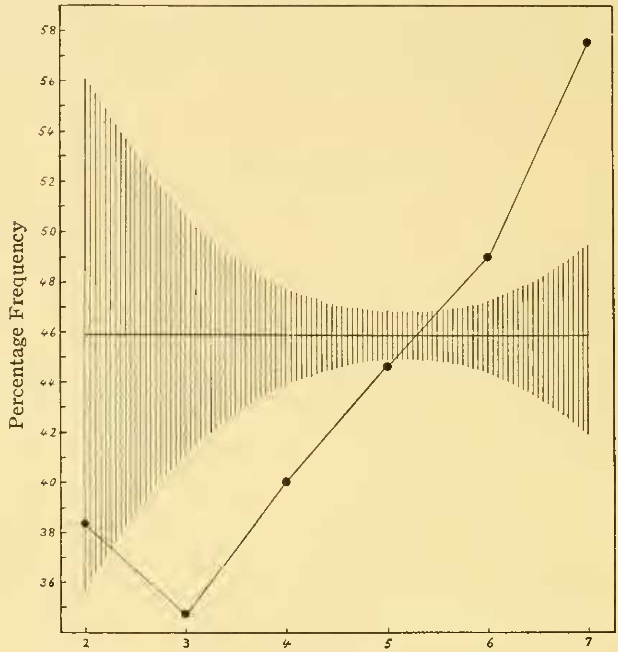

Diagram 1. Percentage of Seeds infested by *Bruchus* in a Golden Wax culture in general and in pods with various numbers of ovules. The general percentage is shown by the central bar, that for the various pod classes by the heavy dots on the ordinates for ovules. The shaded area gives the range of twice the standard deviation of random sampling for samples of the size dealt with. Note that all but one of the percentages for individual ovule classes fall well outside this area.

The diagrams show with great conclusiveness not only that the percentage frequencies of parasitization actually observed in the individual ovule classes differ from the average and that these percentages increase from the lower to the higher ovule grades with considerable regularity, but that for the most part the deviation of these percentages from the average condition is so great that they must unquestionably be regarded as statistically trustworthy. Only in the case of the lowest ovule class of the Golden Wax series is there an exception to

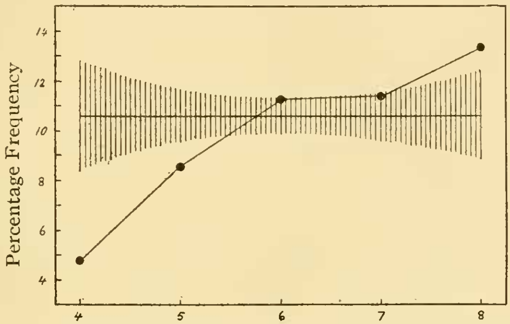

Diagram 2. Relationship between number of ovules per pod and parasitization by *Bruchus* in Burpee's Stringless beans. See Explanation of Diagram 1.

the rule of an increase in percentage of parasitization from lower to higher ovule grades. The graph shows by the enormous extent of the shaded area at the point of two ovules per pod that the probable

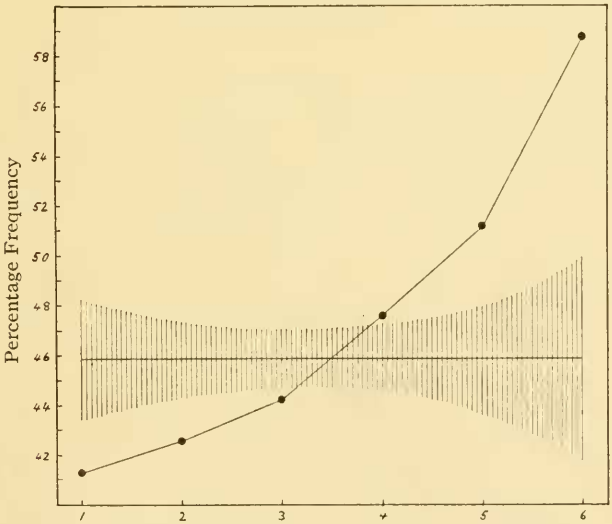

Diagram 3. Relationship between number of seeds matured per pod and parasitization by *Bruchus* in Golden Wax beans.

error for this class of pods is very high indeed. As a matter of fact this empirical percentage is the only one which falls well inside the zone of possible untrustworthiness. Even it lies far below the line indicating the general condition.

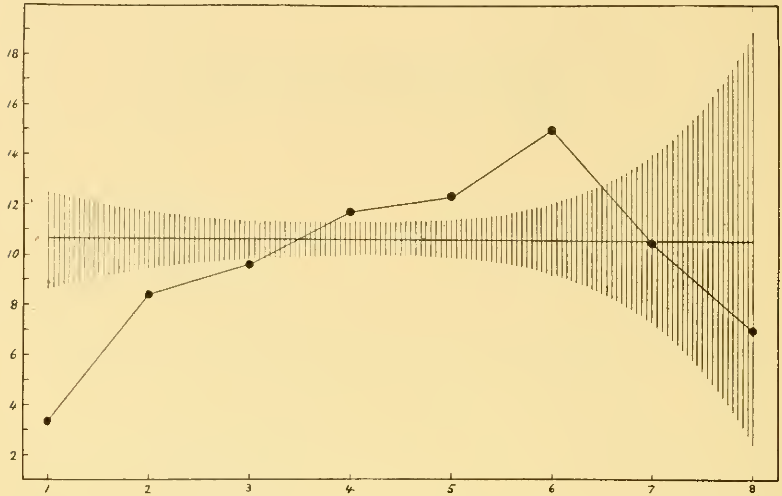

Diagram 4. Relationship between number of seeds matured per pod and percentage frequency of weevils in Burpee's Stringless beans.

Problem II.—Relationship between the Number of Seeds Matured per Pod and the Percentage of Infested Seeds.

In Tables III–IV the records for the seeds have been arranged according to the number of seeds developed per pod instead of the number of ovules originally laid down. The method of computation is the same as that employed in the preceding tables. The graphs, 3–4, are prepared in a manner similar to those described above.

The tables and graphs show the same kind of relationship for number of seeds as for number of ovules per pod. As the number of seeds matured per pod becomes larger the percentage of the seeds which are infested by weevils increases.

In the Golden Wax series the curve of increase in percentage of parasitization from pods with the lowest to the highest number of seeds matured is remarkably smooth. In the Burpee's Stringless material the increase is not quite so regular. Indeed there is an apparent

TABLE III.

INFESTED SEEDS IN GOLDEN WAX BEANS.

Seeds per Pod.	Total Seeds.	Infested Seeds.	Per Cent. Infested.	Seeds Weighed.	Ratio to Weighed.
1	1,649	681	41.30	349	1.951
2	4,666	1,987	42.58	936	2.123
3	6,114	2,706	44.26	1,143	2.368
4	5,228	2,491	47.64	945	2.636
5	2,950	1,512	51.25	502	3.012
6	606	356	58.75	63	5.651
	21,213	9,733	45.88	3,938	2.472

TABLE IV.

INFESTED SEEDS IN BURPEE'S STRINGLESS BEANS.

Seeds per Pod.	Total Seeds.	Infested Seeds.	Per Cent. Infested.	Seeds Weighed.	Ratio to Weighed.
1	1,071	46	4.30	548	.084
2	3,052	259	8.49	1,610	.161
3	4,596	441	9.60	2,280	.193
4	4,408	518	11.75	1,925	.269
5	3,195	396	12.39	1,222	.324
6	1,770	266	15.03	576	.462
7	427	45	10.54	97	.464
8	56	8	7.00	20	.400
	18,575	1,979	10.65	8,278	.239

decrease in pods with 7 and 8 seeds. Here, however, the number of seeds available is small as compared with the other pod classes; as the graphs show, these aberrant percentages fall within the limits of twice the standard deviation from the general percentages, and hence cannot be given too much weight.

The facts presented in the preceding paragraphs show beyond reasonable doubt that the incidence of the so-called bean weevil is not purely random, but that it is to some extent determined by the character of the pods in which the seeds are borne. In pods with larger numbers of ovules and in those with larger numbers of seeds the percentage frequency of infested seeds is higher. One might expect that if one and one only of the two characters of the pod here considered, *i. e.*, number of ovules and number of seeds, were the determining factor in the differential parasitization of the seeds there would nevertheless be some relationship between the other pod character and incidence of parasites. Thus suppose that the factor which determined the differences in the frequency of parasitization of pods of different classes were number of ovules formed per pod, and that the number of seeds developing had no independent influence in determining whether a seed should or should not be parasitized. Nevertheless on tabulating his data according to number of seeds per pod one would actually find the percentage frequency of parasitism to some extent dependent upon, or modified by, the number of seeds matured per pod, for the simple reason that the number of seeds matured is within limits determined by the number of ovules originally laid down.

The problem of differentiating these two factors is in the present case one of some complexity, and demands for its final solution further observations of various kinds.

One may make some progress by a two-fold classification of the data already in hand. By sorting the records for the individual

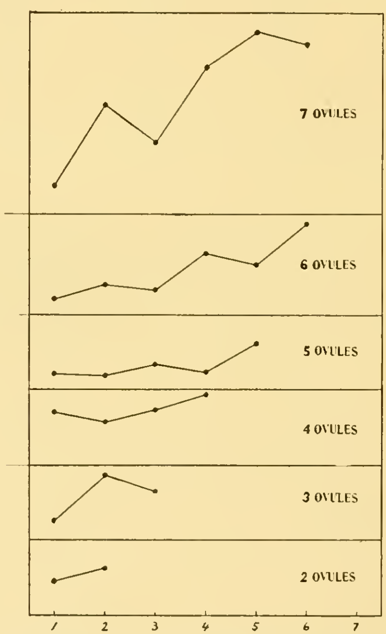

Diagram 5. Relationship between number of seeds matured per pod and percentage frequency of *Bruchus* for pods with various numbers of ovules. Golden Wax beans.

seeds first into classes according to the number of ovules formed per pod, and then sub-sorting each ovule class according to the number of seeds which its pods mature, one may ascertain whether there is a relationship between number of seeds maturing and relative numbers parasitized independent of that between the number of ovules formed and the incidence of the parasites.

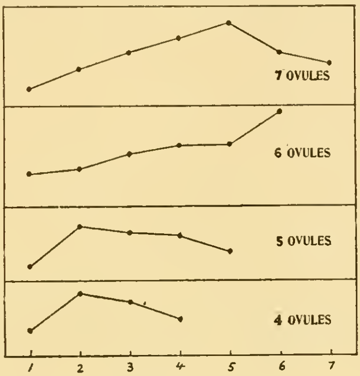

Diagram 6. Relationship between number of seeds matured per pod and percentage frequency of *Bruchus* for pods with various numbers of ovules. Burpee's Stringless beans.

The results can best be presented graphically in diagrams 5 and 6. Here the percentage of parasitization in pods with different numbers of seeds matured is shown for pods with each class of ovules separately.

The results are very irregular just as one would expect when the data are split up into such numerous sub-classes. There seems, however, to be a distinct tendency for a higher percentage of parasitization to occur in pods with larger numbers of seeds, even when the number of ovules is made constant by working with pods all having the same number of ovules. Thus number of seeds matured seems to be of independent, though probably of minor, significance in determining frequency of parasitization. Further than this the analysis cannot be pushed at present.

Problem III.—Relationship between the Position of the Seed in the Pod and the Percentage of Parasitized Seeds.

At the beginning of these studies an entomological friend suggested that the factor most likely to influence the distribution of the weevils among the seeds would be their position in the pods.

The data have been tabulated to test this point, but I can find no trustworthy evidence of any such relationship.

RECAPITULATION AND DISCUSSION OF RESULTS.

The purpose of the foregoing paragraphs is the presentation of certain matters of fact concerning the relationship between the characteristics of the pod of the common bean, *Phaseolus vulgaris,* and the relative frequency of parasitization by the so-called bean weevil, *Bruchus.*

The results of the examination of the extensive series of data representing two quite dissimilar horticultural varieties comprising 6,233 and 8,018 pods producing 18,575 and 21,213 seeds respectively show that the chance of occurrence of a weevil or of weevils in a seed is to some degree dependent upon the number of ovules laid down and upon the number of seeds developing in these pods.

In pods with larger numbers of ovules the relative number of the seeds which are weevil infested is greater.

Percentage of parasitization also increases as the number of seeds matured per pod becomes larger.

Since number of seeds matured and number of ovules formed per pod are positively correlated[1] *i. e.,* since pods with larger numbers of ovules produce on the average larger numbers of seeds, a relationship between either of these characters and the incidence of weevils would necessarily result in some relationship between the other character and frequency of parasitization, even though there were no direct causal relationship between them.

It is difficult to differentiate and to measure the independent influence of these two characters upon the incidence of the insects.

Apparently the number of seeds matured has some influence independent of that of the number of ovules per pod with which it is correlated. Since this relationship seems to be slight, it is probable that the number of ovules laid down is the primary factor.

The most reasonable hypothesis in explanation of the observed relationships would seem to be that in the young pod size is corre-

[1] Harris, J. Arthur, Arch. f. Entwicklungsmech. d. Organism., 35: 500–522, 1912.

lated with the number of ovules formed and the number of seeds which are beginning to develop, just as they are known to be in matured pods of other forms,[1] and that in consequence the maintenance of a foothold and ovoposition are easier in such pods. That is, however merely a suggested hypothesis which must be confirmed or disproved by actual behavior studies.

No relationship between the position which a seed occupies in the pod and its liability to parasitization has as yet been demonstrated.

MISCELLANEOUS NOTES.

Shooting Insects with a Bean-Shooter.—The easiest way to collect some cicadas is to shoot them with fine shot. But the carrying of a pistol for the purpose is apt to get one in trouble in some communities, for in many places a license to carry firearms is required. As yet there is no such restriction on carrying a bean-shooter, and when properly made it can be used most effectively in collecting certain wary insects, like several species of dragonflies. The bean-shooter or sling, is made with the forked stick and rubber bands in the usual way, but the leather bag should have a well secured stitch on each end, so that it will hold several hundred fine shot. Armed with this contraption the entomologist may repair to the side of a pond or stream, and as some desirable though tantalizing dragonfly sails by just out of the reach of the ordinary net, it may be shot on the wing. The insect will probably fall into the water, but may be rescued with a long stick, or one can go in wading for it. If a dragonfly keeps out of the reach of a net to its own advantage, it generally does another thing greatly to its disadvantage, and that is, it will repeatedly fly by the same spot, thus giving the collector several chances.

With a bean-shooter made after the above described plan, the writer this past summer shot a number of dragonfles, both on Long Island and on Staten Island, and only in two instances were the insects at all damaged. In the majority the effects of the shot were not noticeable.

As to the shooting of cicadas, a correspondent to whom I had

[1] Harris, J. Arthur, Bot. Gaz., 50: 117–127, 1910; *loc. cit.*, 53: 204–218, 396–414, 1912.